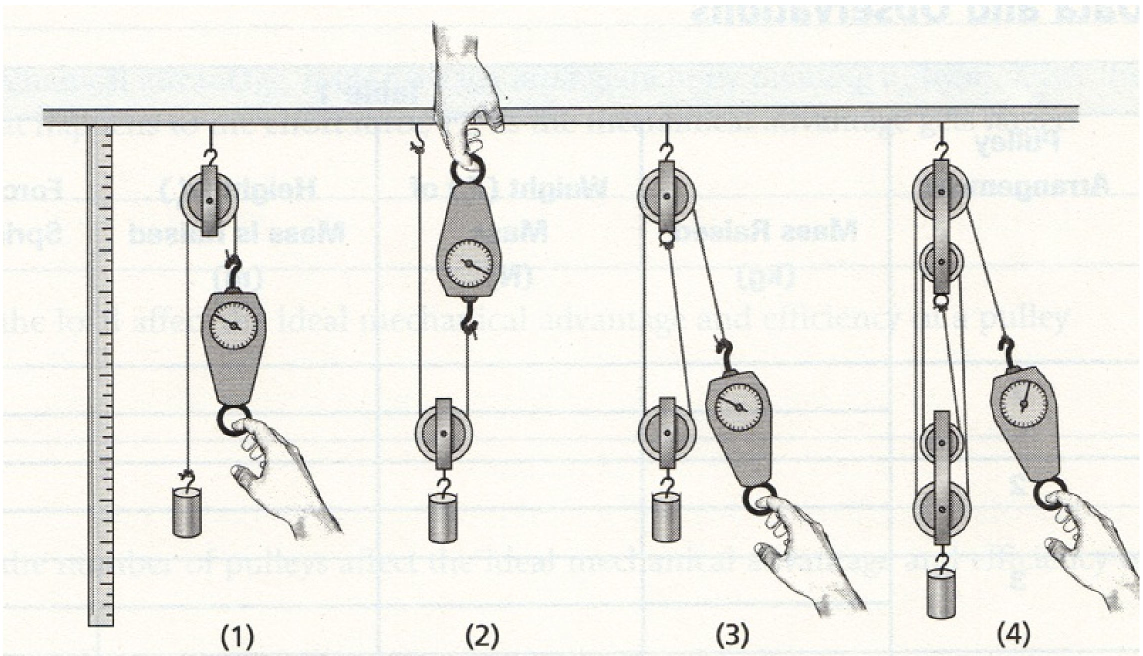
MND Physics

Simple Machines - Pulleys

Pulleys are simple machines that can be used to change the direction of a force or to reduce the force needed to move a load through a distance. Pulleys, like other simple machines, do not change the amount of work that is required. The effort force, however, can be reduced if it's applied over a greater distance. We can express the work relationship as work "W" equals force "F" times distance "d":

$$W = F_{||}\, d$$

EQUIPMENT:
Table H- rack system with hooks, 2 meter sticks, spring scale, 2 single pulleys, 2 double pulleys, string, scissors, mass set.



In the procedure, you will be asked to identify the number of "lifting strands" or strings. This number is the number of strings that are actually contributing to lifting the weight.

In case 1, only one strand or string is doing the lifting i.e. only one string attached to the weight. The other string not directly lifting the weight. Now compare that to case 3 where the weight actually is supported by a pulley (the lower one in the picture) which incorporates 2 strings i.e. 2 strings are helping to lift the weight. Case 2 is somewhat of a special case: again, a pulley is directly attached to the weight and 2 strings are attached to that pulley. There are, therefore, 2 lifting strings.

Using the above analysis, you should be able to deduce the number of lifting strands/strings for case 4.

PROCEDURE:

Part 1:

1. Set up the apparatus as shown in figure 1.
2. IMPORTANT: Calibrate (zero) the scale!
3. For trial 1, select the 200 g mass.
4. Cut enough string so that the mass can sit on the desktop, loop through the pulley and attach to the spring scale near the pulley (as shown).
5. Record the weight of the mass in Newtons in your data table.
6. Carefully raise the mass by pulling on the spring scale. Measure the distance the mass is raised in meters (d_r). Measure the distance you pulled the spring scale in meters (d_e). A convenient pulling distance is somewhere around a half a meter: you are free to choose your own convenient pulling distance making sure you record the actual value used.
7. Record the scale value (Newtons) in your data table as “spring scale force”.
8. Record the number of lifting strands in Table 2.

Part 2:

9. Set up the apparatus as shown in figure 2.
10. IMPORTANT: Re-calibrate (zero) the scale!
11. For trial 2, use the 200 g mass.
12. Use the string you prepared for trial 1. The mass should begin the trial on the tabletop.
13. Record the weight of the mass in Newtons in your data table.
14. Carefully raise the mass by pulling on the spring scale. Measure the distance the mass is raised in meters (d_r). Measure the distance you pulled the spring scale in meters (d_e). A convenient pulling distance is somewhere around a half a meter: you are free to choose your own convenient pulling distance making sure you record the actual value used.
15. Record the scale value (Newtons) in your data table as “spring scale force”.
16. Record the number of lifting strands in Table 2.

Part 3:

17. Set up the apparatus as shown in figure 3.
18. IMPORTANT: Re-calibrate (zero) the scale!
19. For trial 3, use the 200 g mass.
20. Cut enough string so that the mass can sit on the desktop, loop through the pulleys and attach to the spring scale near the TOP pulley.
21. Record the weight of the mass in Newtons in your data table.
22. Carefully raise the mass by pulling on the spring scale. Measure the distance the mass is raised in meters (d_r). Measure the distance you pulled the spring scale in meters (d_e). Use a pulling distance that you feel is suitable for your application.
23. Record the scale value (Newtons) in your data table as "spring scale force".
24. Record the number of lifting strands in Table 2.

Part 4:

25. Set up the apparatus as shown in figure 4.
26. IMPORTANT: Re-calibrate (zero) the scale!
27. For trial 3, use the 500 g mass.
28. Cut enough string so that the mass can sit on the desktop, loop through the pulleys and attach to the spring scale near the TOP pulley.
29. Record the weight of the mass in Newtons in your data table.
30. Carefully raise the mass by pulling on the spring scale. Measure the distance the mass is raised in meters (d_r). Measure the distance you pulled the spring scale in meters (d_e). Use a pulling distance that you feel is suitable for your application.
31. Record the scale value (Newtons) in your data table as "spring scale force".
32. Record the number of lifting strands in Table 2

DATA:

TABLE 1					
Pulley Arrangement	Mass Raised (kg)	Weight of Mass (N)	Height Mass is Raised (m)	Force Spring Scale (N)	Distance Scale moves (m)
1					
2					
3					
4					

TABLE 2					
Pulley Arrangement	Work Out $W = Fd_r$ (j)	Work In $W = Fd_e$ (j)	IMA (d_e/d_r)	Number of Lifting Strands	Efficiency %
1					
2					
3					
4					

ANALYSIS:

- Find the efficiency of each system. Why can the efficiency never be greater than 100%?
- Look at your IMA results. What happens to the effort force as the IMA gets larger?
- Discuss all possible sources of error. HINT: Work is related to energy. Were there any losses of energy as you preformed your trials? (EX: Did you hear any noise(s) as you lifted the weight? What caused the noise?) If you believe there was energy lost, how might that possibly effect your data?

DISCUSSION:

Explain why the statement "a machine reduces the amount of work you have to do" is false.